

Use of Sediment Quality Guidelines and a Weight of Evidence Approach in the Assessment of Sediment Contamination

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Objectives:

- Describe a weight-of-evidence approach for assessing contaminated sediment: USEPA GLNPO draft “Guidance Manual to Support the Assessment of Contaminated Sediments in the Great Lakes Basin.”
- Summary of standard methods for testing sediments.
- Example data sets illustrating predictions of sediment toxicity in freshwater and marine environments using sediment quality guidelines (SQGs).
- Field-validation of chronic laboratory toxicity tests.

**“The weight of evidence required
should depend on the weight of the
decision”**

Dave Mount
USEPA, Duluth, MN
SETAC short course
November 1997

Assessing sediment contamination:

- Interpret historical data
- Identify potential problem chemicals or areas at a site
- Design monitoring programs
- Classify hot spots and rank sites
- Make decisions for more detailed studies
- Evaluate the control of problem chemicals
- Link chemical sources to sediment contamination
- Trigger regulatory action
- Establish target remediation objectives

Standard methods* for sediments:

METHOD	ASTM	EPA	ENVIRON CAN
Toxicity: Fresh water	E1706	1994a, 2000	1997a,b
Toxicity: Marine	E1367, E1611	1994b, 2001a	1992a, 1997
Toxicity: Soil	E1676	1986	1994a, 2001?
Bioaccumulation	E1688	1989, 1994a, 2000	none
Collection	E1391	2001b	1994b
Manipulation	E1391	2001b	1995
Guidance	E1525	2001b	1996b
Quality Assurance	E1525, E1706	2001b	1992b, ISO 9000

Figure 3.3. Relationship between ecosystem goals, objectives, indicators, metrics, and targets (USEPA 2001).

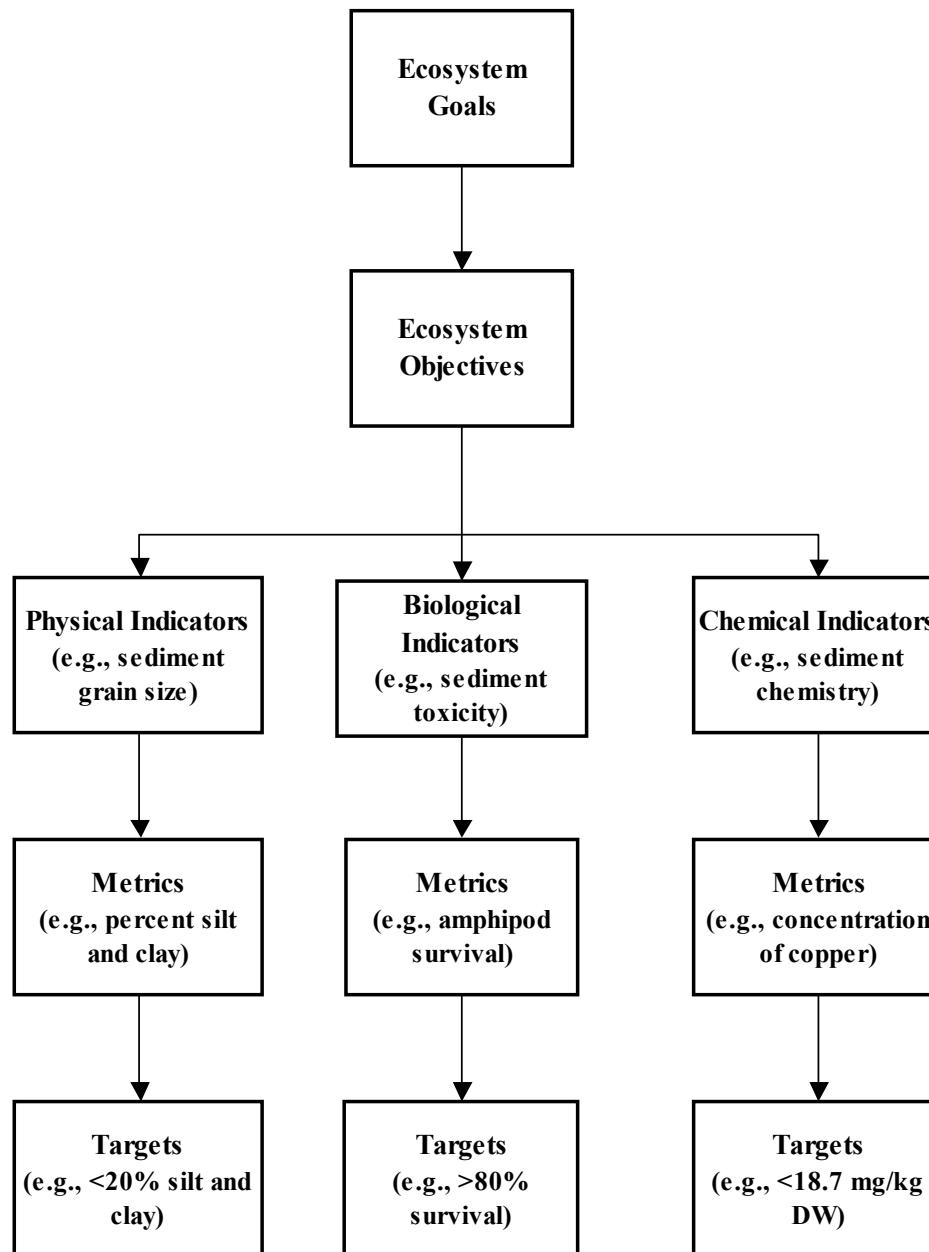
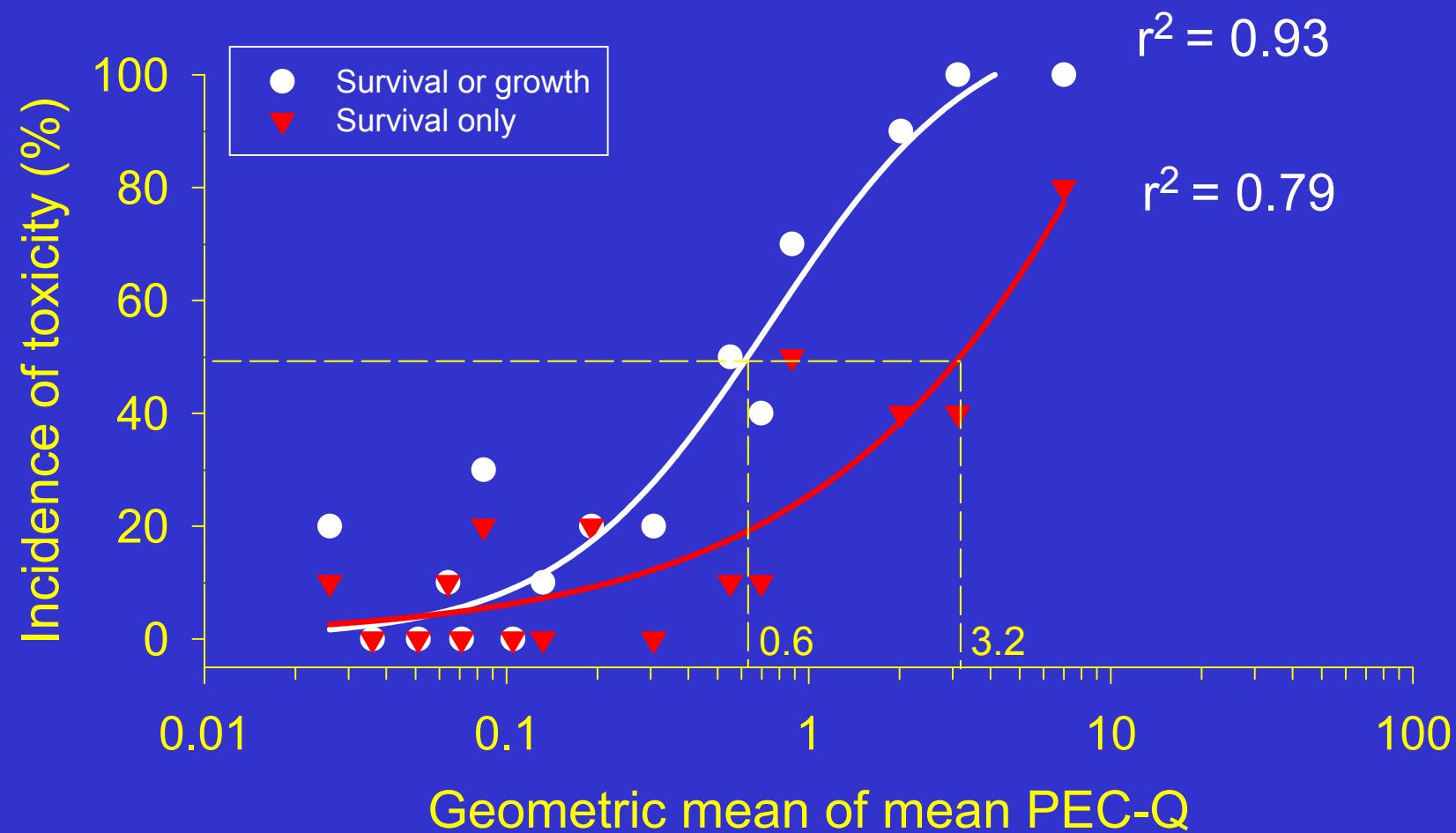


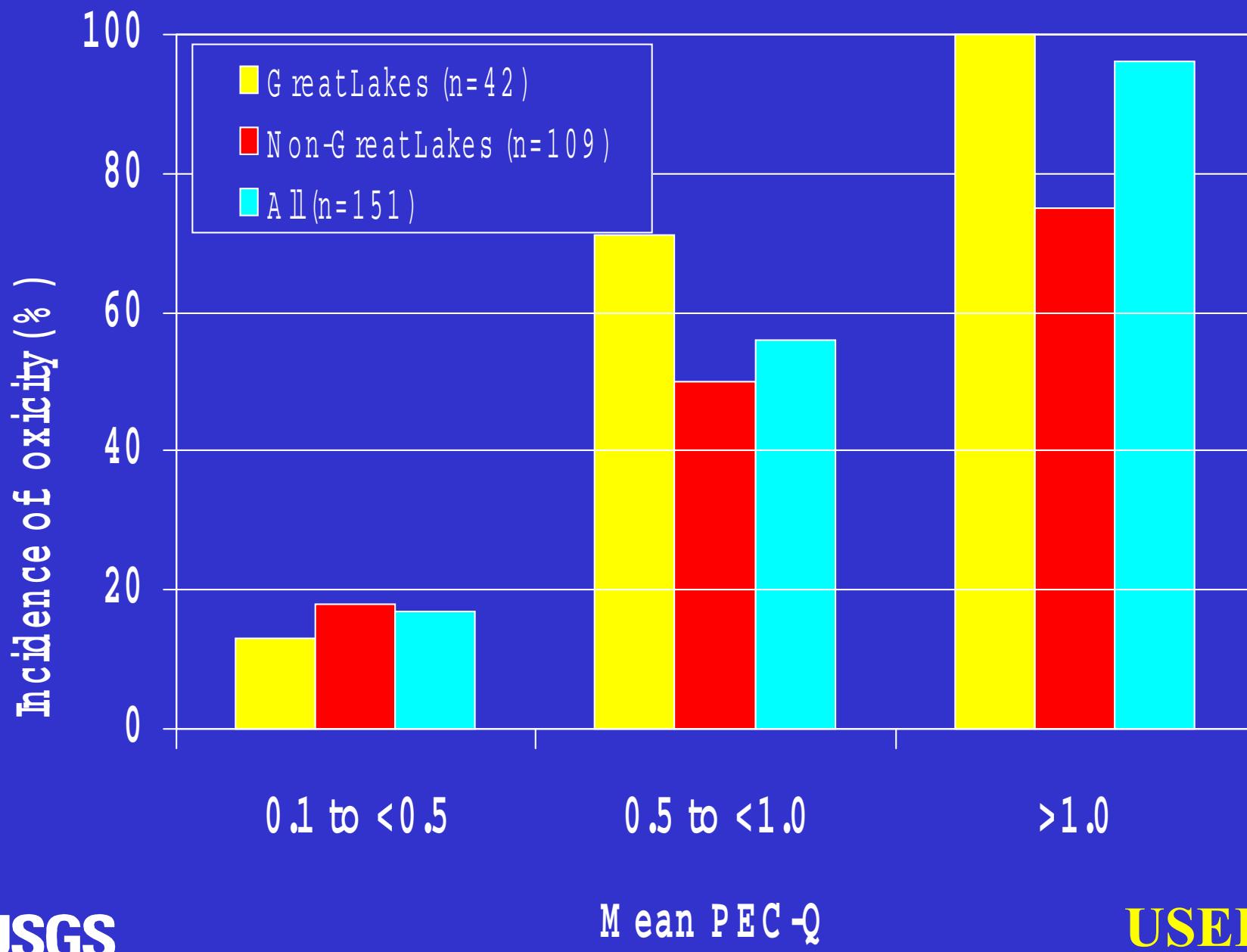
Table 8.3. Contingency table for assessing impacts of contaminated sediments on aquatic life based on four separate indicators of sediment quality.

Possible outcomes	Sediment chemistry	Toxicity test	Benthic community	Tissue chemistry	Possible Conclusions
1	+	+	+	+	Impact highly likely: Contaminant-induced degradation of sediment-dwelling organisms in the field and bioaccumulation evident.
2	-	-	-	+	Impact unlikely: Contaminant-induced degradation of sediment-dwelling organisms in the field not evident, tissue residues due to exposure to water or diet, possibly from other sites.
3	+	-	-	+	Impact on higher trophic levels likely: Contaminants not toxic to sediment-dwelling organisms; bioaccumulation evident.
4	-	+	-	+	Impact likely: Unmeasured factors contributing to toxicity and bioaccumulation evident.
5	-	-	+	+	Impact likely: Effects on organism in the field probably due to sediment contamination and bioaccumulation evident.
6	+	+	-	+	Impact likely: Toxic chemicals probably stressing sediment-dwelling organisms; bioaccumulation evident.
7	-	+	+	+	Impact likely: Unmeasured contaminants contributing to toxicity and bioaccumulation is evident.
8	+	-	+	+	Impact likely: Toxicity tests not sensitive enough and bioaccumulation is evident.
9	+	+	+	-	Impact highly likely: Contaminant-induced degradation of sediment-dwelling organisms evident; limited bioaccumulation.

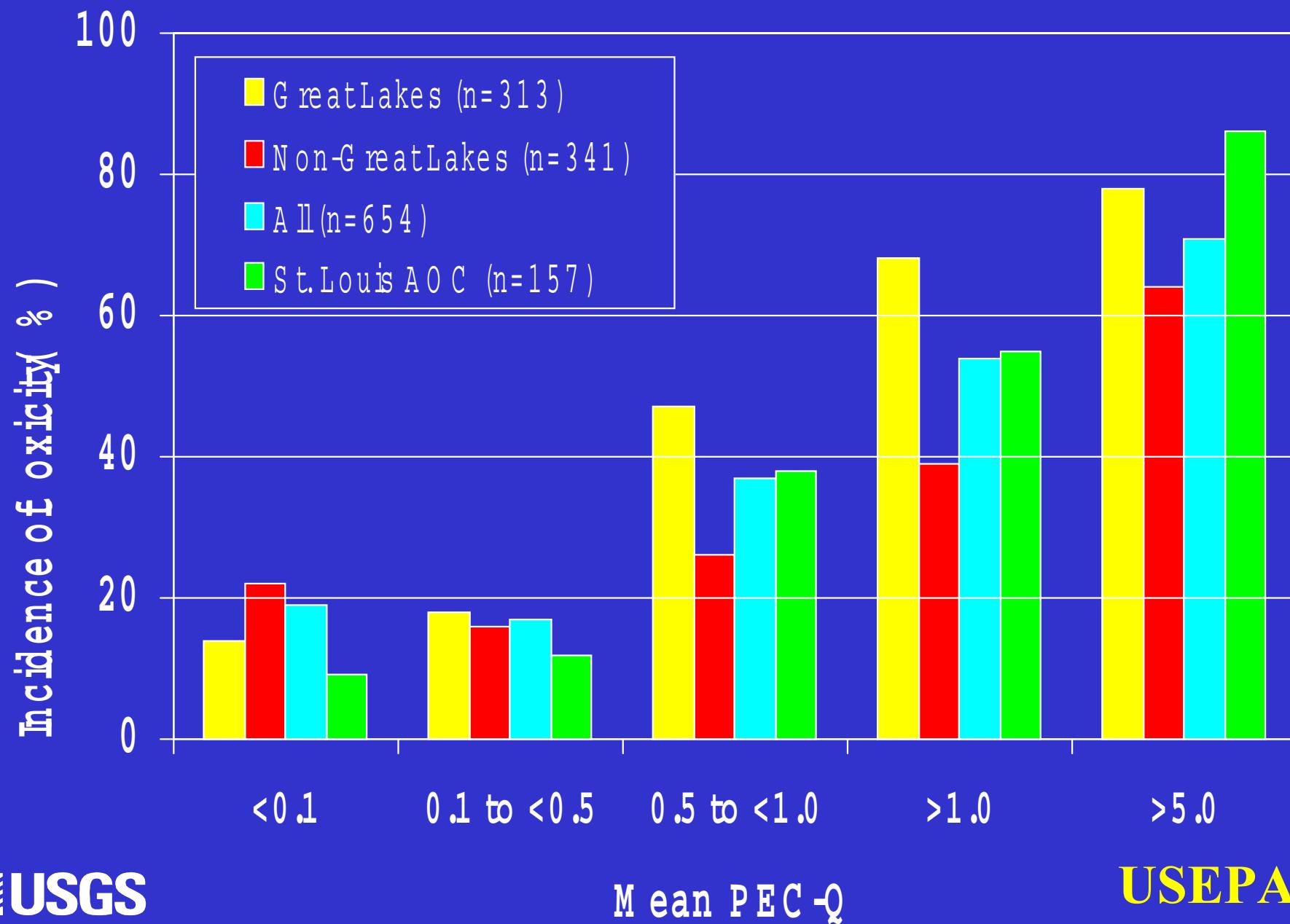
28- to 42-d *Hyalella azteca*



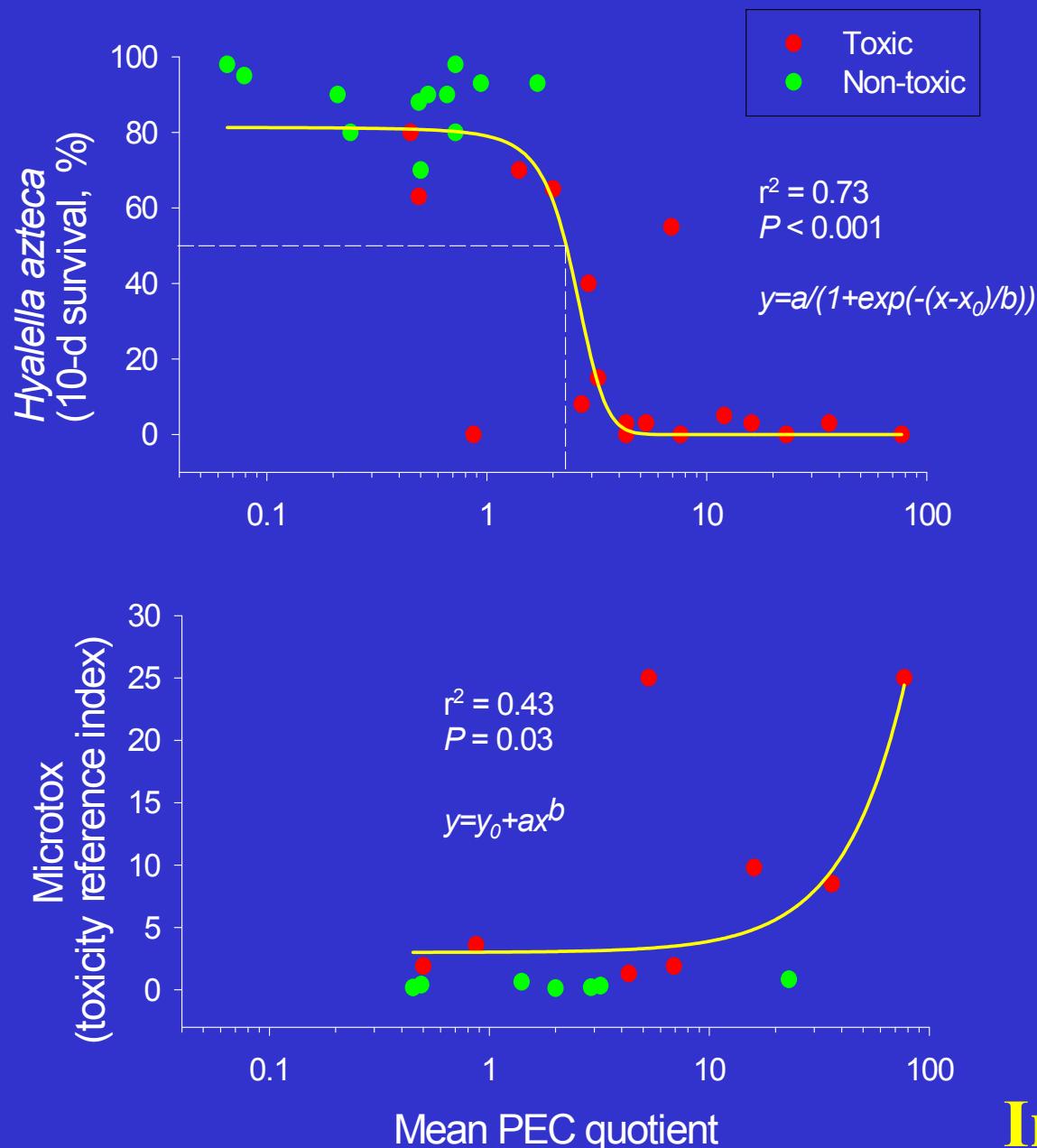
Geographic incidence of sediment toxicity: HA28 test



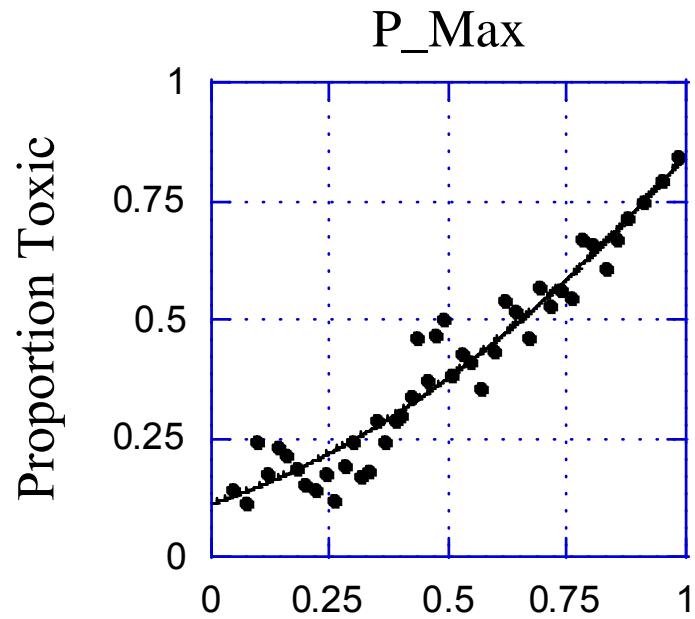
Geographic incidence of sediment toxicity: HA10 test



Hyalella azteca and Microtox: Toxicity vs. Mean PEC-Q

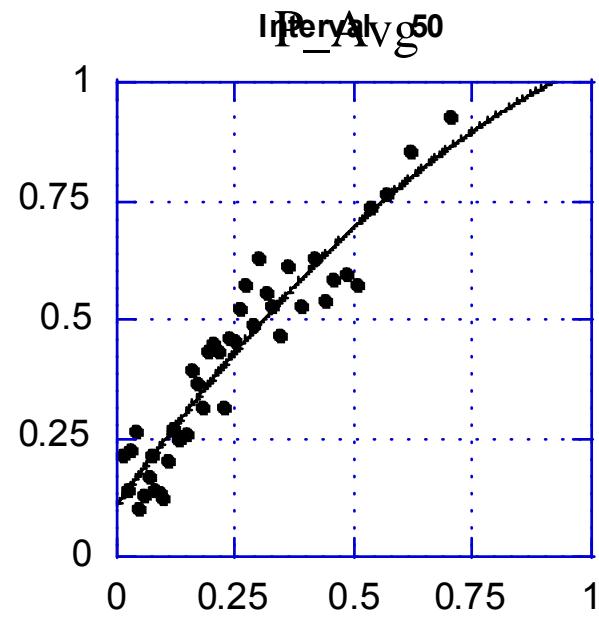


Logistic regression: Combined models (Field et al. 2000)



Maximum Probability

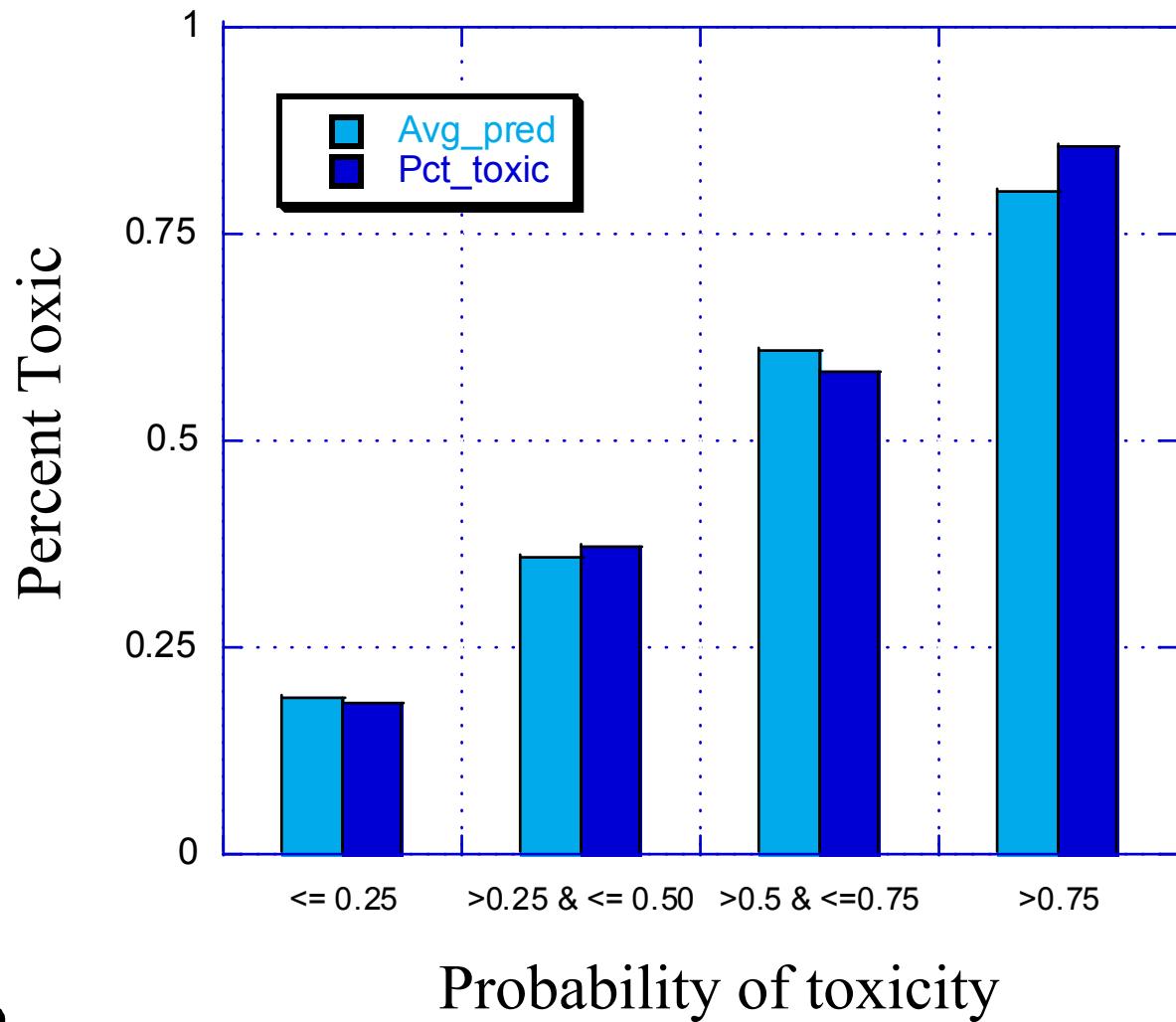
$$Y = 0.11 + 0.33x + 0.40x^2 \quad \square$$
$$R^2 = 0.93$$



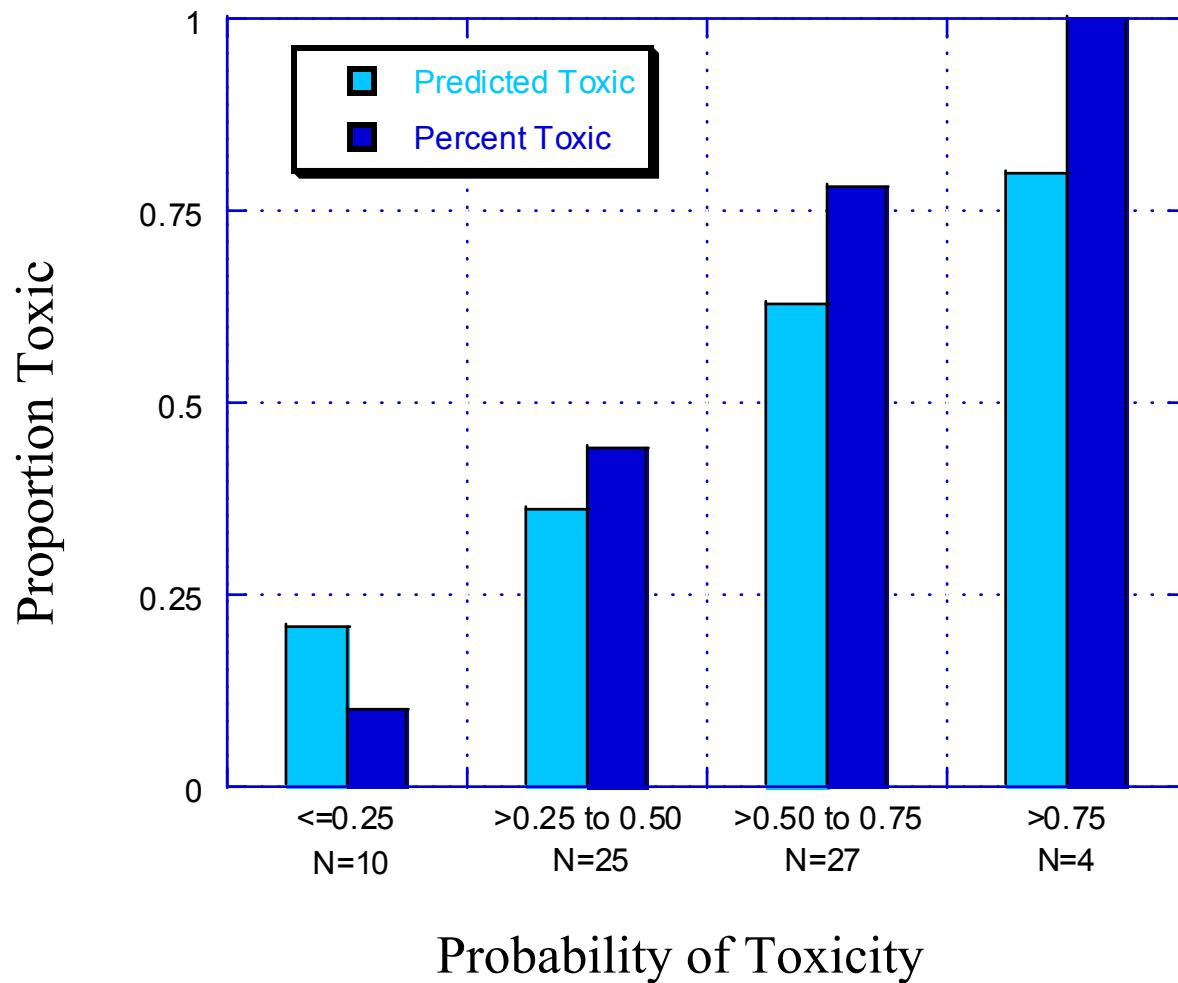
Mean Probability

$$Y = 0.11 + 1.42x - 0.48x^2 \quad \square$$
$$R^2 = 0.89 \quad \square$$

Logistic regression: Reliability of P_Max Model (Field et al. 2000)



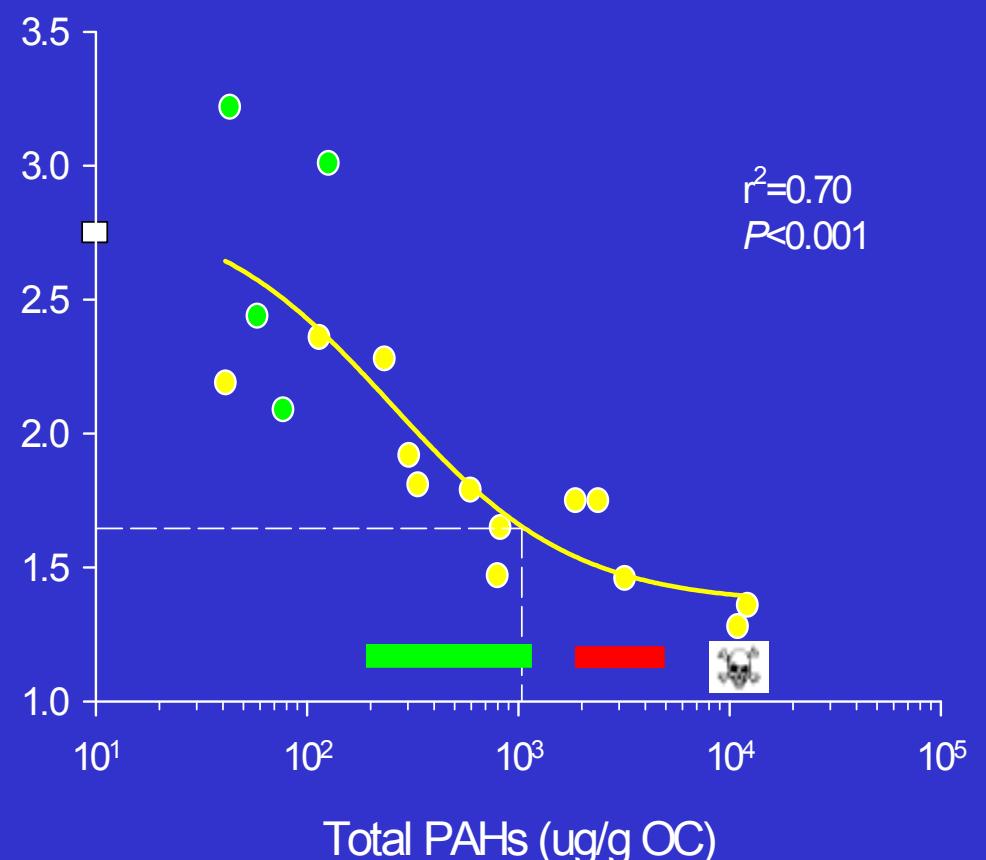
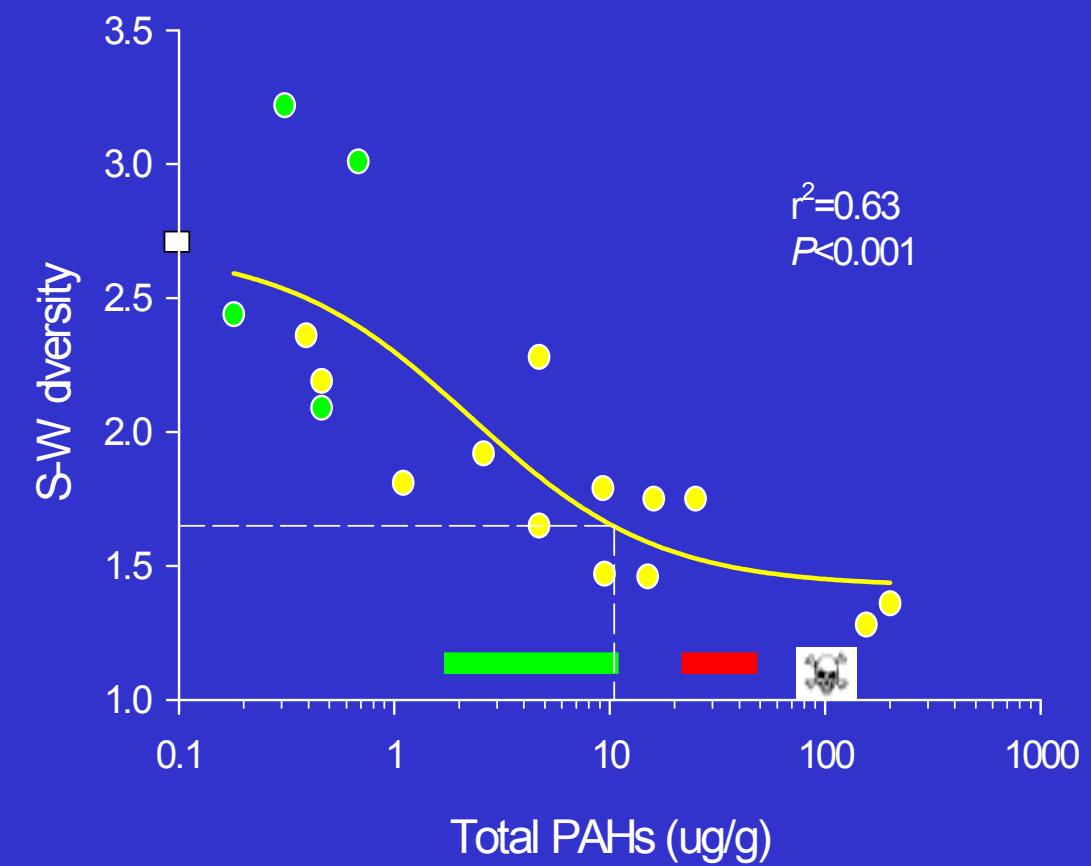
Logistic regression: Application to Independent Data Set of the Calcasieu estuary (Field et al. 2000)



Thresholds for PAH-contaminated sediments

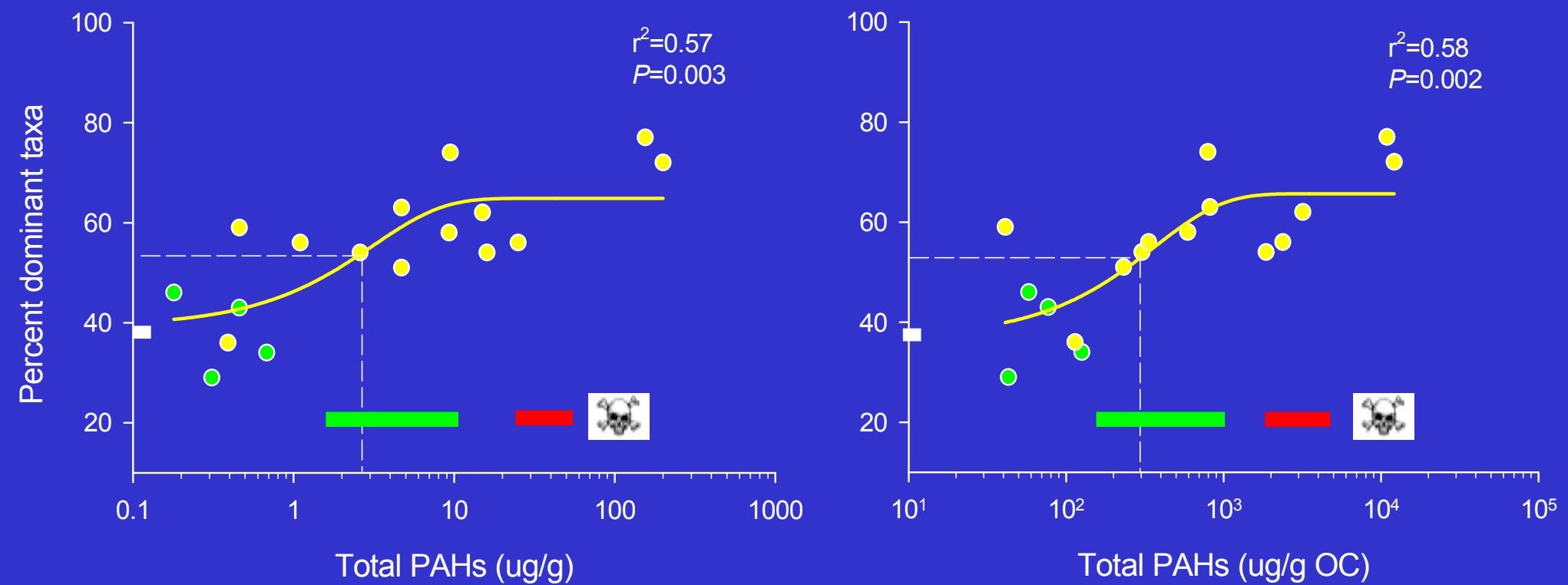
ENDPOINT	THRESHOLD (dry)	THRESHOLD (oc)
Site specific: Benthic community	2 to 10 ug/g	400 to 1000 ug/g
Site specific: <i>H. azteca</i> 10-d LC50	4.89 ug/g	500 ug/g
CHRONIC:		
EqP: Swartz (1999)	2.11 ug/g	211 ug/g
USEPA (1999)	8.65 ug/g	865 ug/g
Di Toro and McGrath (2000)	9.86 ug/g	986 ug/g
Empirical: TEC (marine)	2.9 ug/g	290 ug/g
TEC (freshwater)	1.6 ug/g	160 ug/g
ACUTE:		
Spiked sediment: <i>R. abronius</i> 10-d LC50:	23.9 ug/g	2,387 ug/g
EqP: Di Toro and McGrath (2000)	50.2 ug/g	5,017 ug/g
Empirical: MEC (marine)	18 ug/g	1,800 ug/g
PEC (freshwater)	22.8 ug/g	2,280 ug/g
SEVERE:		
Empirical: EEC (marine)	100 ug/g	10,000 ug/g

Shannon-Weiner Diversity at PAH-contaminated sites



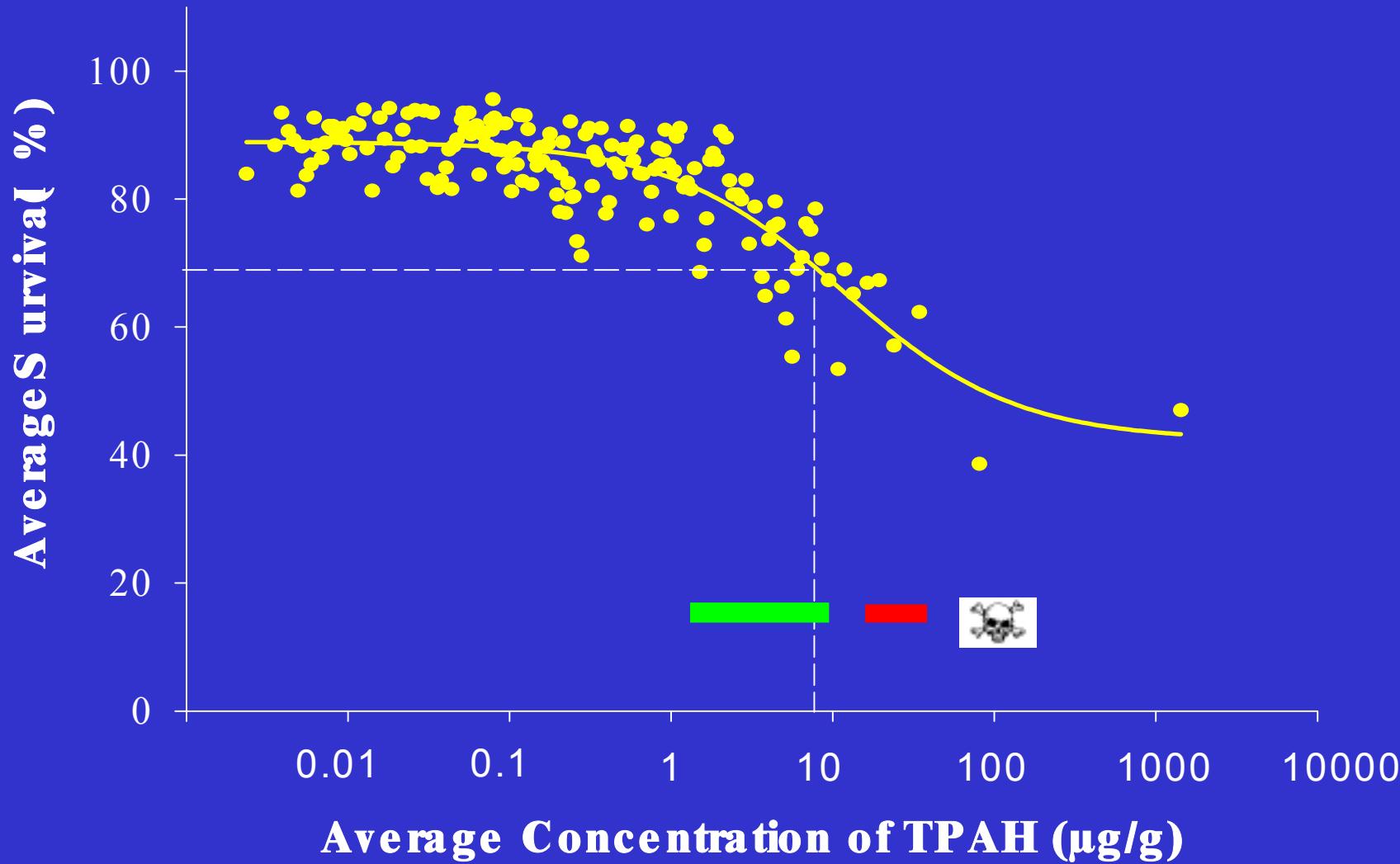
MacDonald and Ingersoll (2001)

Percent Dominant Taxa at PAH-contaminated sites

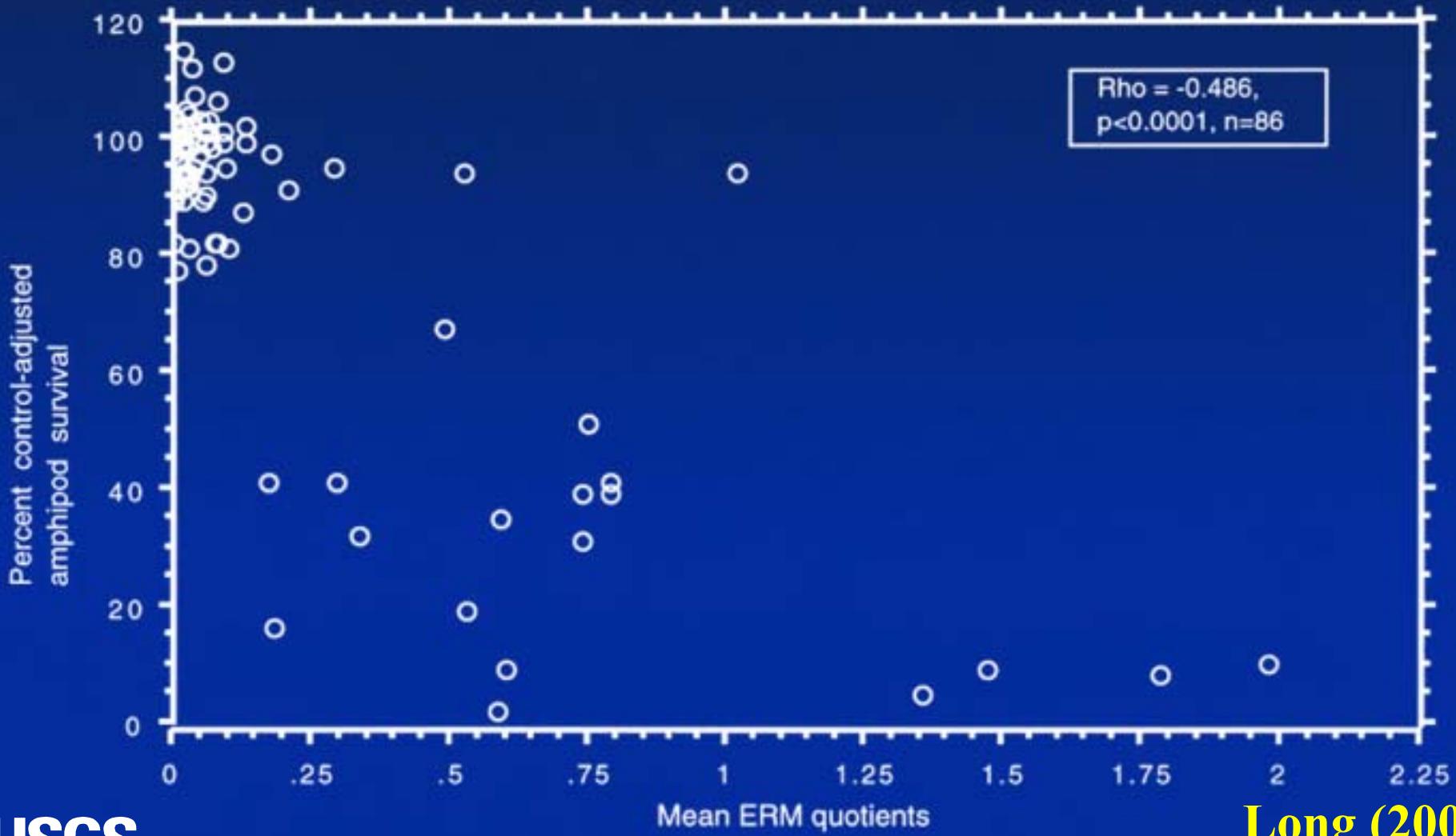


MacDonald and Ingersoll (2001)

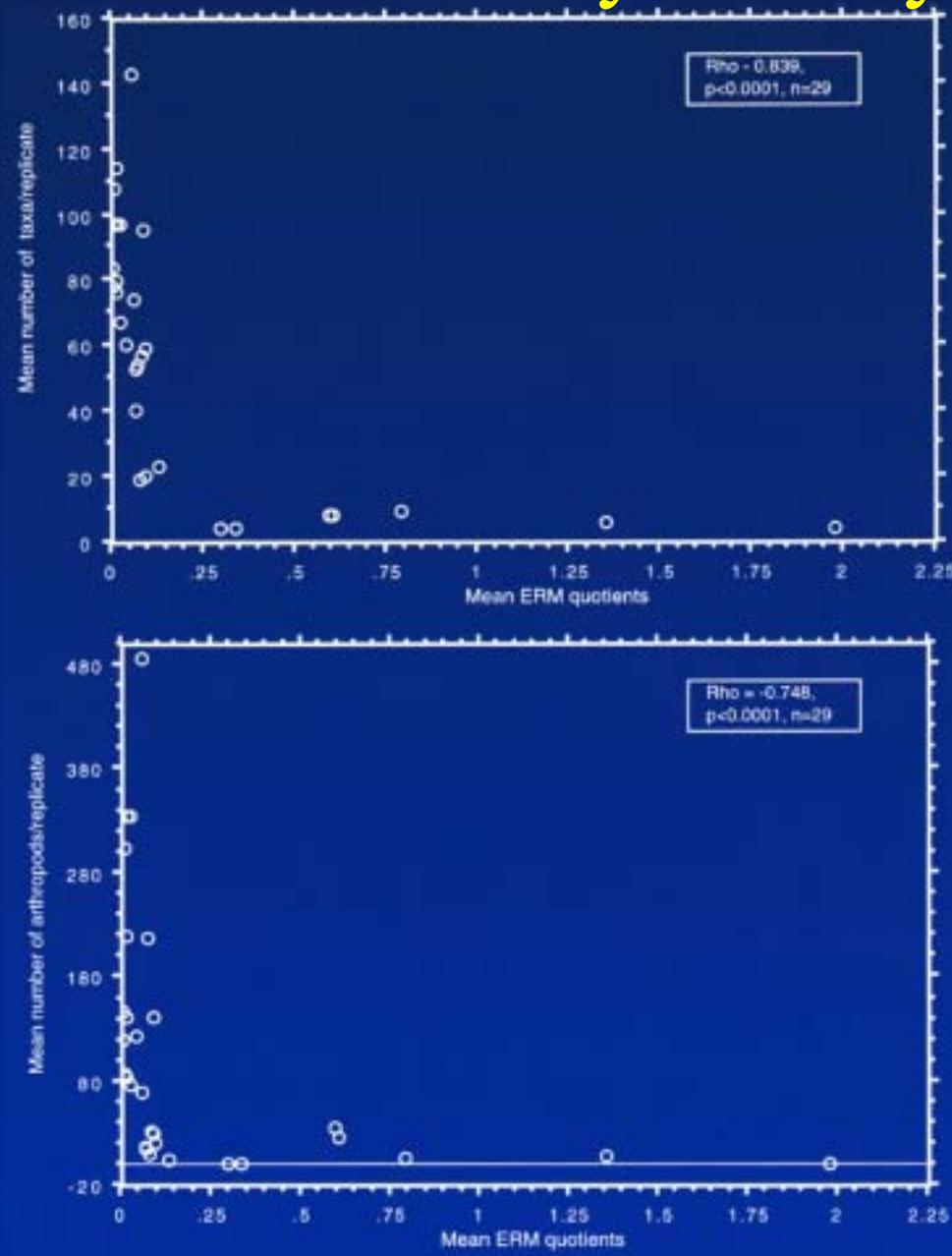
10-d Toxicity with Marine Amphipods



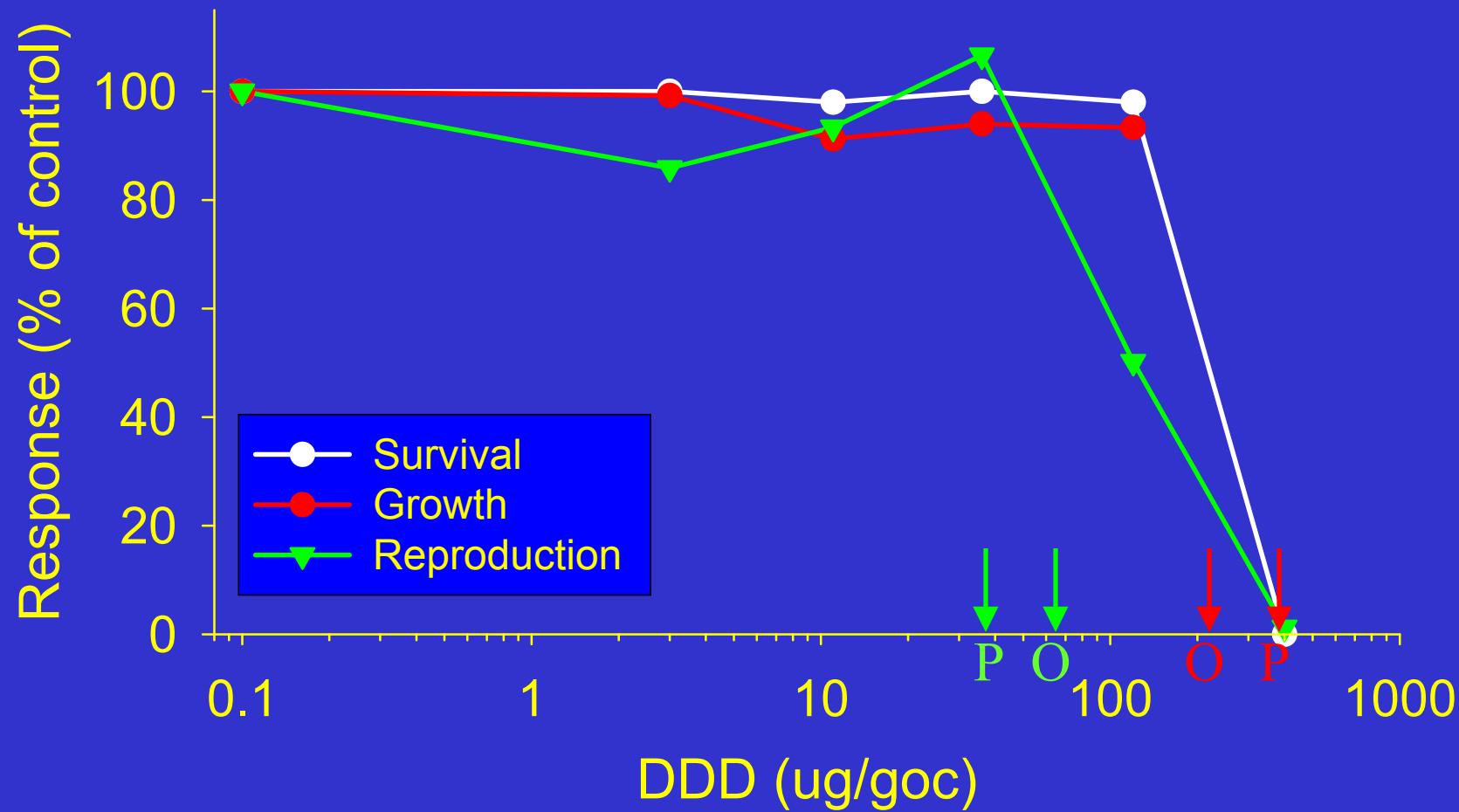
Amphipod toxicity: Biscayne Bay



Benthic community: Biscayne Bay

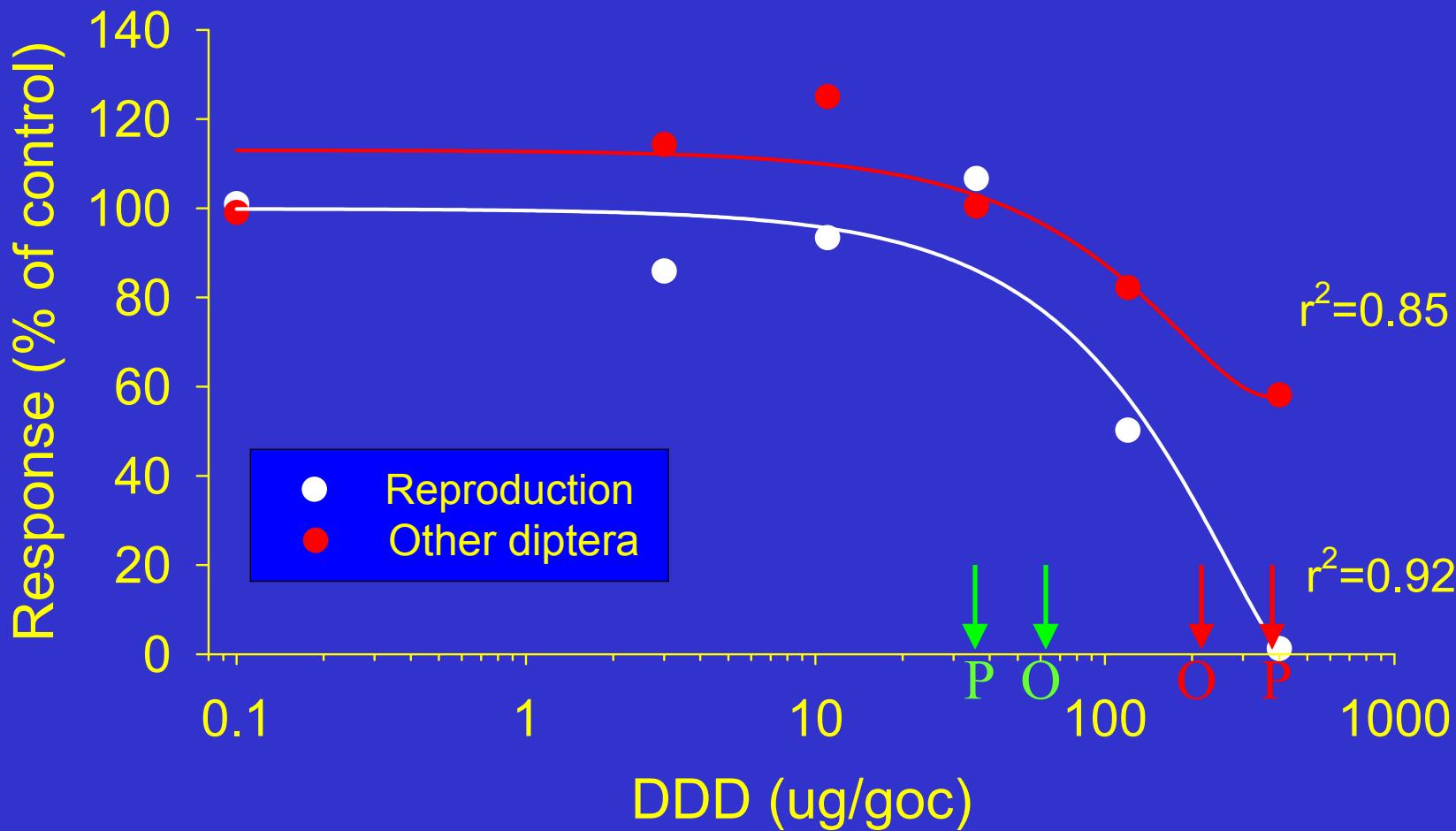


Chronic Laboratory Exposures with *Hyalella azteca*

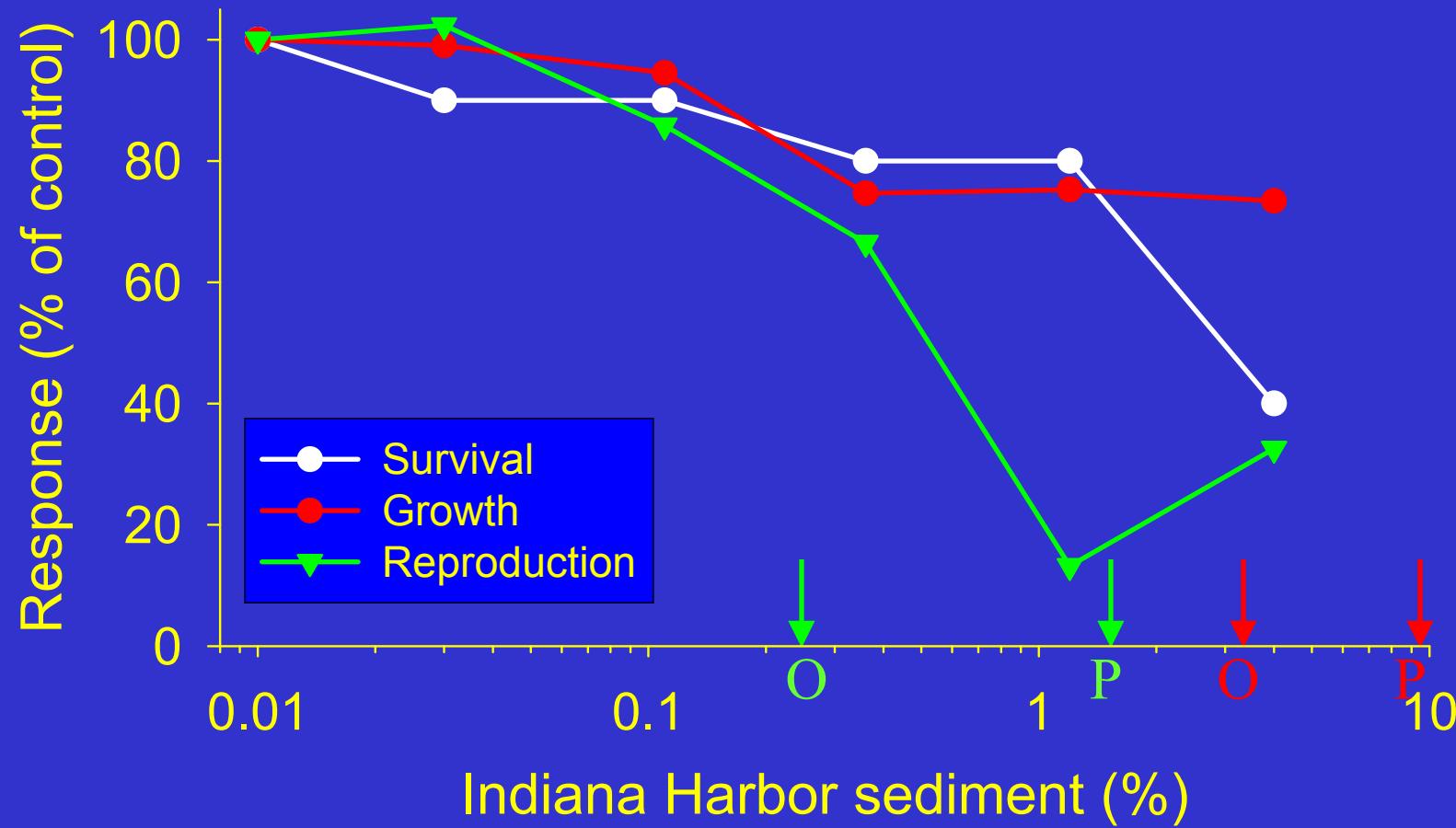


Hayward et al. (2001)

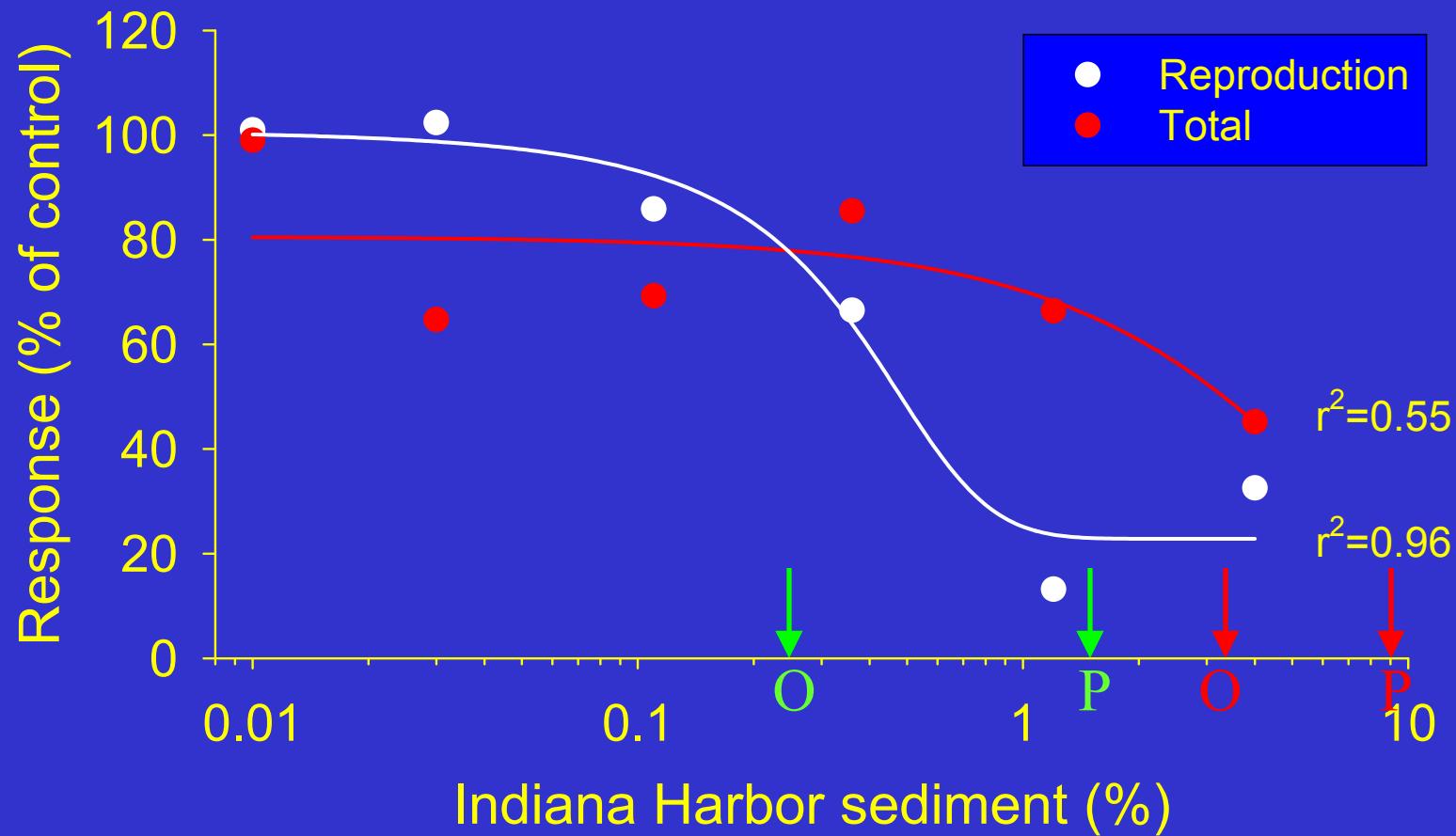
Comparison of Sensitive Endpoints from the Lab and Field Studies with the DDD Sediments



Chronic Laboratory Exposures with *Hyalella azteca*



Comparison of Sensitive Endpoints from the Lab and Field Studies with the Indiana Harbor Sediment Dilutions



Conclusions:

- Weight-of-evidence approach should be used to assess contaminated sediments.
- SQGs are reliable and predictive of sediment toxicity in samples from across North America.
- Chronic freshwater sediment toxicity tests are about 6x more sensitive than the 10-d tests.
- Laboratory tests predictive of field effects particularly when chronic tests are evaluated.